Urban Forest Canopy Expansion in Hamilton: A Quantitative Assessment of Planting Strategies, Mortality, Lifespan, and Long-Term Sustainability

Projecting Canopy and Biodiversity Outcomes for Hamilton, Ontario: Comparison of current City practice and a large-scale planting alternative

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Abstract

Hamilton, Ontario currently has an estimated 5,000,000 trees and an urban forest canopy of approximately 21%. City Council has set a 40% canopy target and approved a planting rate of 20,000 trees per year, yet no timeline for achieving this target has ever been provided.

This study evaluates the mathematical feasibility of reaching 40% canopy under the City's existing program and compares it with an alternative strategy designed to maximize canopy growth, biodiversity, and long-term forest sustainability, **while staying with the current City budget.**

This report evaluates two planting scenarios:

1. Option A — Current City Program (20,000/yr)
2. Option B — Sustained High-Volume Program (200,000/yr)

The analysis incorporates literature-based 5–7-year establishment survival rates, spacing-adjusted canopy multipliers, long-term lifespan projections by planting type, and ecosystem impacts such as self-seeding capacity.

Results show that Hamilton's current plan (Option A) of 20,000 trees per year is **mathematically incapable of achieving 40% canopy** — even over several centuries — because annual mortality rapidly exceeds annual planting, and low-density traditional street planting lacks regenerative capacity.

In contrast, a 200,000 trees/year program (Option B) as modelled would achieve the 40% canopy target in approximately 31 years.

By postponing expensive Street Tree planting and allocating this money to a Sustained High-Volume program this can be achieved within existing budgets.

Introduction and Objectives

Hamilton's urban forestry goals include expanding the citywide canopy (Urban Forest Canopy Study) and improving local biodiversity (Biodiversity Action Plan). The current municipal target is 20,000 trees per year, and achieves neither of these.

Canopy growth occurs only after trees survive their critical 5–7 year establishment window. This analysis therefore evaluates planting outcomes using realistic survival assumptions.

Option A — Current City Plan

- 20,000 trees/year
- Includes 6,000 Street Trees per year
- Includes 5,000 Free Trees per year
- Includes 9,000 Community Trees per year

Option B — Sustained High-Volume Program

- 200,000 trees/year until 40% canopy is achieved
- Utilizes "Active Nature Area" concept in public parks and accessible open spaces - includes "Miyawaki Forest" and shade tree areas along with open space
- Focuses on remediation of industrial areas within the "CODE RED" ward areas (Wards 2, 3, 4, 5) that the study designates as a **Special Environmental Zone**

Definitions

Miyawaki Forest

A Miyawaki forest is a small, dense, biodiverse urban forest created using methods designed by Japanese botanist Akira Miyawaki, which involves planting many native trees and shrubs closely together on prepared soil to rapidly mimic a mature, self-sustaining native forest, establishing complex ecosystems in small spaces (even tennis-court sized) within decades, not centuries. More than 40 million trees worldwide have been planted using this design by Akira's team alone.

Active Nature Area

An Active Nature Area features a combination of different park design strategies including Miyawaki Forests, Shaded Tree areas, grassed and paved pathways, pollinator gardens, thickets and meadows. It has five main purposes: A Connection to Nature; Climate Change Remediation, Urban Canopy Expansion and Increased Biodiversity; Improved Health Outcomes; To Encourage Usage; and to Reduce Mowing and Maintenance.

Street Trees

Street Trees are large caliper trees planted within 5 metres of a roadway either on city-owned land on on city allowances on private property.

Free Trees

Free Trees are small caliper trees that are given away by the City to private residential landowners. This program is limited to one tree per year per address.

Community Trees

Community Trees refers to trees that are neither Street Trees nor Free Trees and are usually planted by volunteer groups working under City supervision. These can be small, medium or large caliper trees.

Special Environmental Zone - CODE RED

This is an area at the north end of the urban core in Wards 2, 3, 4 and 5 which has been and continues to be subject to industrial pollution from the city's largest polluters, including the steel plants. This area is roughly defined by the CN Rail tracks north of Barton Street and Burlington Bay, from Wellington Street in the west to Woodward Avenue and the Red Hill Creek Parkway in the east.

This Analysis Includes:

1. Surviving established trees (post 5–7 years) for each scenario.
2. Resulting canopy area (ha) using spacing-adjusted multipliers.
3. Canopy percentage increase relative to Hamilton's land base.
4. Time to reach 40% canopy under each scenario.
5. Biodiversity and regenerative capacity differences among planting types.
6. Key policy implications for reaching the City's target.

Data, Geometry, and Core Assumptions

City Geometry and Canopy Baseline

- Total land area: 1,118.31 km² (111,831 ha)
- Current canopy: 23,708 ha (~21.2%)
- Target canopy: 44,732 ha (40%)
- Canopy gap to close: 21,024 ha

Tree-to-Canopy Conversion

- ~5,000,000 trees produce 23,708 ha canopy
- Average: 210.9 trees/ha
- Average canopy per mature tree: 0.004742 ha (~47.4 m²)

Spacing-based canopy multipliers (per mature tree):

Planting Type	Multiplier
Free Trees	×1.5
Community Trees	×2.0
Miyawaki (City land)	×0.5
Miyawaki (remediated)	×0.6
Street Trees	×0.8

Survival Definition

Survival is defined as reaching and remaining alive after the 5–7 year establishment period, the highest-mortality window.

Planting Types and Survival Inputs (Mid-Case)

Planting Type	5–7 Year Survival	Rationale
Street Trees	25%	Restricted root volumes, high stress from traffic exhaust, road salt, heat exposure from adjacent impermeable surfaces. Very poor structural soil support
Free Trees	65%	Homeowner care by motivated owners
Community Forest	55%	Good soils; widely spaced
Miyawaki (City land)	60%	Biodiversity-first density
Miyawaki (remediated)	80%	Engineered soils boost survival

Option A: Current City Planting Program

Annual Planting Mix (20,000 trees) and Survival Rates

- 6,000 Street Trees (25% survival)
- 5,000 Free Trees (65% survival)
- 9,000 Community Trees (70% survival in park soils)

Budget Breakdown ($3.3M)*

- 6,000 Street Trees × $320 = $1,920,000
- 5,000 Free Trees × $10 = $50,000
- 9,000 Community Trees × $150 = $1,350,000
- **Total = $3,320,000**

**Budget is estimated based on available information*.*

Street Trees consume 58% of the total budget but produce negative canopy growth.

Break-Even Mortality Across Planting Types

Planting Type	Annual Trees Planted	Annual Survivors after 7 Years	Annual Mortality of Existing Trees	Net Gain or (-Loss)
Street Trees	6,000	1,500	6,720	**(-5220)**
Community	9,000	6,300	812	**5,488**
Free Trees	5,000	3,250	46	**3,204**
Total	20,000	11,050	7,578	**3,472**

Total net canopy expansion per year 7: +3,472 trees.

If the City continues with Option A Hamilton would require ~1,440 years to reach 40% canopy.

Option B: Sustained High-Volume Program (200,000/yr)

Annual Planting Mix (200,000 trees) and Survival Rates

- 15,000 Free Trees (65% survival)
- 92,500 Miyawaki in parks (60% survival)
- 92,500 Miyawaki on remediated industrial land (80% survival)

Budget Breakdown ($3.3M/year)*

Free Trees

- 15,000 trees X $10 = $150,000

**Budget is estimated based on available information*.*

Miyawaki Area Cost and Tree Totals

- Cost: $50/$m^2$
- Area plantable per stream: 31,500 m^2
- At 3 trees/m^2 → 94,500 trees per stream
- Total Miyawaki: 189,000 trees
- $1,575,000 — Miyawaki (parks)
- $1,575,000 — Miyawaki (remediated)
- **Total = $3,300,000**

At this scale, Hamilton reaches 40% canopy in ~31 years and is within the current City budget

Discussion

Biodiversity vs. Canopy Efficiency

Miyawaki forests produce:

- high biodiversity
- dense multi-layered structure
- Smaller individual crowns than open plantings

Community Planting and Free Trees produce:

- more canopy per tree
- far less biodiversity.

Remediation as a High-Leverage Action

Survival improves dramatically on remediated land (60% → 80%).
This creates:

- higher long-term survival
- larger total canopy
- faster development of soil ecosystems

Scale and Survivorship

Two foundational lessons:

1. Scale matters most.
   The only path to rapid canopy expansion is sustained high-volume planting.
2. Survival determines everything.
   Remediation and establishment care are force multipliers.

Sustainability: Self-Seeding and Long-Term Forest Dynamics

Why Self-Seeding Matters

Self-seeding enables:

- exponential forest growth
- natural succession
- long-term canopy expansion without perpetual planting

The Street Tree Problem

Hamilton's Existing Street Tree Population:

- 168,000 Street Trees

Street Trees are:

- costly
- low-survival
- short-lived
- non-regenerating

Key Result: Street Tree Decline

- Street Trees live ~25 years
- Current annual mortality of existing trees: ~6,720
- Annual new street trees at 7-year survival: ~1,500
- Net loss: ~5,220 Street Trees/year

Conclusion:

Street Trees cannot contribute meaningfully to canopy growth. City reports show 19,000 Street Trees are already dead and require replacement.

Which Plantings Regenerate?

Planting Type	Self-Seeding Potential
Street Trees	None
Free Trees	Minimal
Traditional Forest	Limited
Miyawaki (parks)	**Strong**
Miyawaki (remediated)	**Strongest**

Only Miyawaki systems produce positive ecological reproduction.

Limitations

- No allowance has been included for unpredictable influences such as pests, disease, climate change effects, etc. These may affect outcomes.
- Survival rates are mid-case assumptions, not guarantees.
- Canopy-per-tree multipliers simplify complex biological variation.
- Remediation survival assumes appropriate soil engineering.

Policy Implications and Recommendations

1. Create a new internal hierarchy within City Hall combining the departments of Climate Change Urban Greening, Parks, Forestry, Horticulture and Biodiversity with new leadership and a mandate to follow Best Practices as outlined in this Report and recommended by the Vineland Research & Innovation Centre (of which the City is a member).

2. Give Forestry priority control over all green spaces within the city, including open spaces in parks, and a clear mandate to create a 40% canopy within 31 years (or sooner).

   This is in keeping with the findings and recommendations of the Urban Forest Canopy Study.

3. Adopt a sustained 200,000/year annual tree planting program.

4. Partner with industry and invest in soil remediation and planting on industrial lands in the north end Special Environmental Zone.

5. Plant Miyawaki forests where biodiversity is a priority.

6. Expand Free-Tree programs for cost-effective survivorship. This would include allowing multiple trees per address and increasing the total number available each year.

   This would require a sustained marketing campaign to connect tree value to personal and family health benefits and city pride.

7. Postpone the Street Tree program for five years and task the Horticulture Department (which currently grows 250,000 flowers per year) to grow enough trees to meet the City's ongoing replacement needs. This would save the City approximately $1.2 million per year versus the cost of purchasing large caliper trees.

8. Follow the guidelines of the Vineland Research & Innovation Centre regarding site preparation and tree placement guidelines.

9. Treat establishment care as essential, not optional. The City currently conducts no site preparation or soil remediation.

Conclusions

1. Hamilton's current 20,000/year planting plan cannot achieve the City's 40% canopy mandate due to break-even mortality and the low survival/lifespan of Street Trees.

2. A Sustained High-Volume Program can achieve 40% canopy within a single generation. Miyawaki systems, especially on remediated industrial land, offer the strongest biodiversity benefits, the highest survivorship, and the only pathway to a self-sustaining urban forest capable of long-term growth.

3. The City's current management structure has contributed to, and continues to contribute to a history of failure to expand the urban canopy. Forestry is restricted from pursuing successful options by a hierarchy that places this department at the bottom of a Public Works chain that is as follows:

    - Public Works
    - Environmental Services
    - Landscape Design
    - Parks & Cemeteries
    - Forestry & Horticulture

    This has created a conflict of priorities which has resulted in 1,300 acres of under-utilized open space and park land best suited for expansion of canopy - as identified by the 10-year Urban Forest Canopy Study (UFS) - remaining inaccessible to Forestry.

    The UFS clearly identified the need to correct this conflict but that requires action from higher authorities, and this has not been enacted by those in the hierarchy above, whose priorities are not canopy.

4. A successful expansion of canopy to achieve the goal of 40% requires intervention from the highest level of City management - The City Manager and The Mayor - to replace a dysfunctional hierarchy. (See Policy Implications and Recommendations #1)

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